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SCHOOLING HABITS OF INJURED AND PARASITIZED MENHADEN¹

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Abstract. We determined from fish collections made along the Atlantic and Gulf coasts that adult menhaden, genus *Brevoortia*, which school with juvenile menhaden in estuarine nursery areas are usually injured or are parasitized with the isopod *Olencira praegustator*, whereas adults in the ocean, bays, and sounds are undamaged. *Olencira praegustator* appears to be debilitatory to menhaden, but the copepod *Lernaeenicus radiatus* does not, except when the fish are heavily infested. When many injured and parasitized adult menhaden are present in an estuary, they form schools independent of the juveniles. Large injured juveniles remain in the nursery areas longer than similar-sized healthy juveniles, and school with the remaining small juveniles.

Key words: Copepod; debilitation; estuary; isopod; menhaden; nursery; parasites; schooling.

INTRODUCTION

The hypothesis that injured fish seek shallow, warm waters when recuperating from injuries has been suggested and the possible advantages of such behavior in the survival of injured fish discussed by Gunter and Ward (1961). Observations we made in the summers of 1956-1969 when seining and trawling for juvenile Atlantic and Gulf menhaden, *Brevoortia tyrannus* and *B. patronus*, in estuarine nursery areas, indicated that many adult menhaden (1 year or older) that schooled with juvenile menhaden (less than 1 year old), were parasitized or had external body injuries. Since menhaden normally school by size (June 1972) and adults do not usually occur in the nursery areas because they are pelagic and spawn at sea (June and Chamberlin 1959), we hypothesized (1) that all adult menhaden occurring in nursery areas in summer and fall and schooling with juveniles are probably injured or parasitized and (2) that they had left schools of adult menhaden in the ocean, bays, and sounds to enter nursery areas, where they then schooled with the only available menhaden, slower swimming juveniles and other injured adults.

In this report the external physical condition of adult menhaden collected with schools of juveniles in Atlantic and Gulf estuaries of the United States in 1970 and 1971 is compared with the condition of adult menhaden collected from commercial catches. The occurrence of large injured juveniles that remain in the estuarine nursery areas late in the fall and school with the remaining small juveniles, is also discussed.

DEBILITATING FACTORS

Menhaden were considered to have a debility if they were injured, parasitized by the isopod, *Olencira praegustator*, or infested with two or more copepods, *Lernaeenicus radiatus*. Injuries ranged from small lesions to missing chunks of flesh or fins; most injuries were caused by predators. The isopod parasite when present in the mouth and especially when actively feeding on the gill filaments of the fish, probably represents a debilitating factor, as indicated by Lewis and Hettler (1968) and Kroger and Guthrie (1972). Lewis and Hettler showed that unparasitized menhaden can survive high temperature better than parasitized menhaden. Since we have commonly observed *L. radiatus* (anchor worms) on menhaden from commercial fishing waters, we do not think a debility results until menhaden become heavily infested.

Menhaden parasitized by the isopod cannot avoid a surface trawl in clear water as well as can healthy fish. In four daytime surface trawl tows made through numerous schools of juvenile Gulf menhaden in Mary Walker Bayou, Mississippi, we caught only 11 juveniles, all of which harbored an isopod. Because menhaden can avoid a trawl in clear water estuaries during the day, representative samples of a juvenile population in these estuaries can be obtained only by trawling during darkness. We made four tows through the same area at night and caught 4,306 juveniles, of which only 0.5% were parasitized. Since the parasitized fish constituted 100% of the catch during the day and only 0.5% of the catch during the night in this bayou, we assumed that those menhaden harboring *O. praegustator* could not avoid the trawl as well as unparasitized fish. We had on two previous occasions caught only parasitized juvenile menhaden in daytime trawl tows made in clear

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TABLE 1. Occurrence of injured and parasitized adult menhaden with juveniles in estuarine nursery areas and with adults in commercial fishing waters

	Length of juveniles (mm)		Length of older fish (mm)		No. of older fish examined; no. injured or parasitized in parentheses
	Mean	Range	Mean	Range	
Atlantic menhaden streams					
Turnbull Creek, FL ^a	71	63-88	123	115-130	2 (2)
Lanceford Creek, FL	73	63-93	120	116-125	12 (7)
Store Creek, SC	93	82-101	137	127-155	6 (6)
Calabash Creek, NC	76	68-86	152	126-191	5 (5)
New River, NC	104	95-110	167	154-180	2 (2)
Folly Creek, VA	102	92-113	160	145-173	5 (5) ^b
White Creek, DE	133	104-160	168	—	1 (1)
Gulf menhaden streams					
Lavaca River, TX	40	24-45	76	67-85	8 (8)
Colorado River, TX	45	37-61	75	66-105	46 (44)
Weeks Bayou, LA	48	35-55	118	—	1 (1)
Bayou Des Allemands, LA	55	48-65	103	—	1 (1)
River Aux Chenes, LA	50	36-66	98	78-140	6 (6)
River Aux Chenes, LA	none caught		86	71-102	100 (0)
Commercial fishing waters					
Cape Hatteras, NC	—		274	241-336	21 (0)
Chesapeake Bay, VA	—		249	215-286	100 (0)
Core Sound, NC	—		198	153-222	523 (6) ^b
Fernandina Beach, FL	—		165	123-203	176 (4) ^b

^a Only yellowfin menhaden were sampled in this stream.^b These fish were considered to have a debility because each was infested with two or more anchor worms.

water of Campbell Creek, North Carolina, but no comparable trawling was done at night.

MENHADEN COLLECTED FROM ESTUARIES

Most adult menhaden collected in summer and fall in estuarine nursery areas in 1970 and 1971 had some type of injury or were parasitized by *O. praegustator* (Table 1). We caught adult Atlantic menhaden lacking external injuries only in Lanceford Creek, Florida. Of about 30 Atlantic coast estuaries where juvenile menhaden were collected, Folly Creek, Virginia, was the only location in which *L. radiatus* was common on adults and where some juvenile menhaden also were infested by this copepod. The only two adult yellowfin menhaden, *B. smithi*, collected with juveniles on the Atlantic coast also were injured. Adult Gulf menhaden captured with juveniles in Gulf of Mexico estuaries also were usually injured or parasitized (Table 1). Schools of small uninjured adult Gulf menhaden, called yearlings, were caught in certain estuaries during the summer (Kroger and Pristas 1973); but the yearlings caught with schools of juveniles in those estuaries were all injured or parasitized. For example, in River Aux Chenes, Louisiana, where we examined fish from a school of uninjured yearling menhaden averaging 86 mm mean fork length (all measurements given are mean fork length), we also captured five injured or parasitized yearlings (90 mm) and one adult (140 mm) that had schooled with the juveniles (50 mm).

In tagging over 50,000 juvenile Atlantic menhaden in estuaries we also noted that the larger injured juveniles which remained in the nursery areas longer than similar-sized healthy juveniles, also schooled with the remaining uninjured fish. In Winnapaug Pond, Rhode Island, in 1969, 1970, and 1971, and in Green Harbor, Massachusetts, in 1970 we observed that all juveniles over 95 mm caught with schools of fish averaging 75 mm, had predator scars, whereas very few of the average-sized fish had injuries. In 1971 we arrived at Winnapaug Pond earlier in the year and also caught schools of juveniles averaging 95 mm; none of them were injured. Evidently, when we arrived in 1969 and 1970, the uninjured population of larger juveniles had left these nursery areas and only the large injured juveniles that were schooled with the smaller juveniles, remained. Similar data were obtained from a sample of a school of juveniles captured in Broad Creek, North Carolina, in December 1971; three injured and 15 parasitized juveniles in the sample averaged 118 mm (range 95-152 mm), whereas the 86 juveniles lacking injuries averaged only 90 mm (76-120 mm). The mean length of the damaged juveniles was significantly greater than the mean length of the undamaged juveniles ($p < .005$). Juveniles of the larger-size class which were tagged in the Broad Creek area in September left the estuary, and some were recovered in November in commercial fishing waters.

Entire schools of injured adult menhaden have

been captured in some estuarine nursery areas. In December 1970 we caught about 400 adult menhaden (estimated 180 mm) in Broad Creek, North Carolina, and closely examined about 100; all were parasitized with *O. praegustator* or had some body injury. On previous occasions large numbers of injured adult menhaden had been captured in Broad Creek in summer and fall, and we also had observed from a bridge that many adults swimming past in schools had flesh wounds. In the estuary of the Newport River, North Carolina, 33 of 35 menhaden (187 mm, range 77–312 mm) collected from a gill net in March 1970 were parasitized or injured; two fish were uninjured. In a small nearby estuary in Bogue Sound, North Carolina, 17 of 18 menhaden (235 mm, range 133–345 mm) collected with a gill net in March 1972 were also parasitized or injured. The seriously injured large menhaden (300 mm) in this sample were emaciated.

MENHADEN COLLECTED FROM COMMERCIAL CATCHES

Most adult Atlantic menhaden examined from catches made in commercial fishing waters were uninjured (Table 1) or showed injuries that had completely healed. For example, of the 523 adult menhaden collected in Core Sound, North Carolina, none had a recent injury but many had scars and missing gill filaments or were parasitized by *L. radiatus*. Sixteen had scars on the dorsal and caudal fins, most of which had almost completely regenerated. Twelve had missing gill filaments as did one adult from the Chesapeake Bay sample, probably the result of a previous infestation with *O. praegustator*; the gill arches and filaments had healed and appeared to be regenerating. Forty-one fish were infested with one *L. radiatus*, five with two copepods, and one with three copepods (Table 1).

In general, none of the old wounds, damage from previous isopod infestation, or infestation by the copepods appeared to impede the adult menhaden collected from commercial fishing waters. The lack of recent injuries and isopod parasites substantiated previous field observations, that only a small percentage of adult menhaden caught in the commercial purse seine fisheries have serious injuries or are parasitized by isopods. The parasitic copepod, however, was frequently observed. We made these obser-

vations when individually tagging and sampling over 100,000 commercially caught adult Atlantic menhaden from 1956 through 1971. Similar observations have been made for adult Gulf menhaden.

CONCLUSIONS

Our first hypothesis that adult menhaden occurring in nursery areas in summer and fall and schooling with juveniles are injured or parasitized, is strongly supported by our numerous collections of adults with external, observable injuries. We did not, as stated in the second hypothesis, determine if injured adults had left schools of fast-swimming adult menhaden in the ocean, bays, and sounds to enter nursery areas. The smaller mean size of the adults which schooled with the juveniles in summer and fall in relation to those caught in the commercial fishery, suggests that some probably had remained in the nursery areas since they were juveniles. The larger size of the injured adults caught in winter in North Carolina estuaries suggests that most of these had left schools of large menhaden in the commercial fishing waters. Our observations of injured and parasitized menhaden, in general, suggest that they recuperate from debilitating factors while schooling with slower swimming menhaden in estuaries, and they do not enter or return to commercial fishing waters until these schools leave the estuaries.

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